EXHIBIT 2

<table>
<tr><th>US7512096B2</th><th>Netgear WAC740 Wireless Access Point</th></tr>
<tr><td>1pre. A method for communicating data over a network between an access point having a first and a second antenna and a first and a second mobile station, the method comprising:</td><td>The accused product practices a method comprises of communicating data over a network between an access point having a first and a second antenna and a first and a second mobile station.

Netgear provides access points to establish a network with mobile devices (or mobile stations). For example, Netgear provides WAC740 4x4 Wave 2 Access Point, which supports the 802.11ac wireless standard. The AP also provides support for Multi-User MIMO. See Fig. 1.

Citation 1: About WAC740

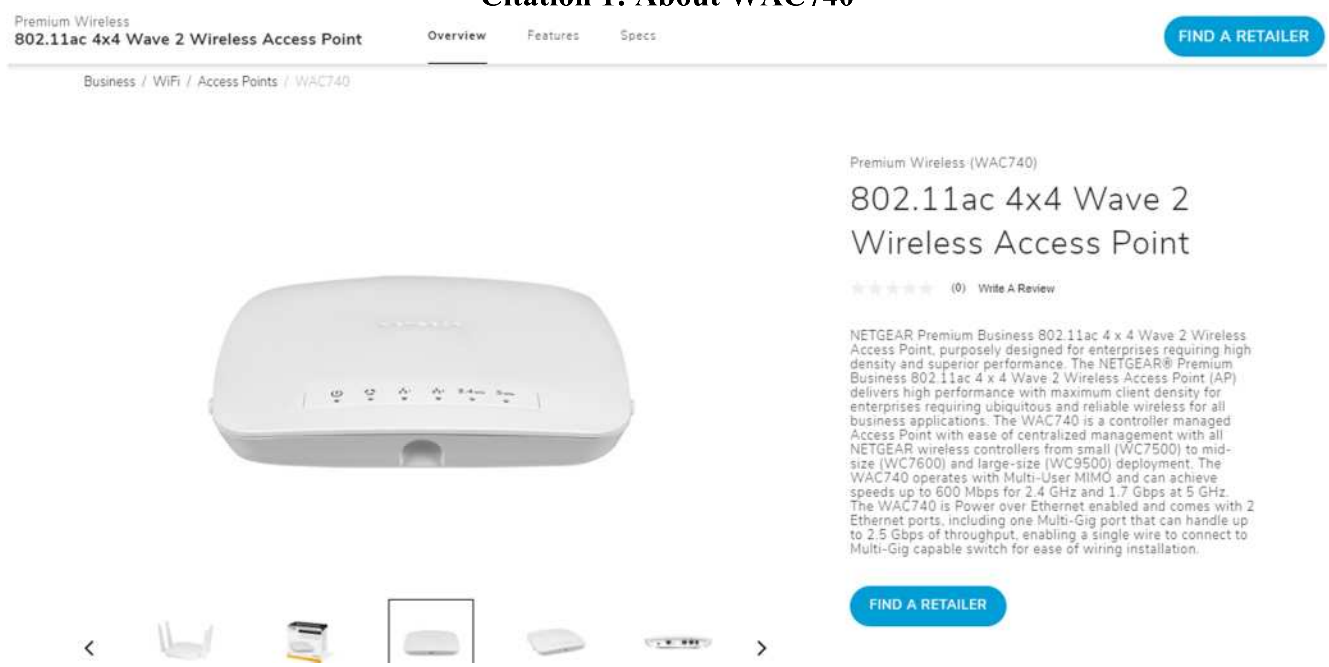

Fig. 1
Source: https://www.netgear.com/business/wifi/access-points/wac740, Page 1, last accessed Feb 08, 2021, Exhibit A</td></tr>
</table>

US7512096B2	**Netgear WAC740 Wireless Access Point**
	WAC740 AP provides wireless coverage with 4 streams of data through optimized 4x4 internal antennas (first and second antenna) for receiving and transmitting. The AP allows multiple AP to clients (mobile station) network transmissions. The AP uses Multi User-Multiple Input Multiple Output (MU-MIMO) technology to deliver data to multiple clients simultaneously over the network. In this manner, the access point forms a network connection with at least a first and a second mobile station. See Fig. 2 and Fig. 3. **Citation 2: Product highlights** Product Highlights • Features 802.11ac Wave 2 technology providing a theoretical aggregate throughput of 2.3Gbps—roughly double the rates offered by today's high-end 802.11ac access points • Reliable wireless coverage with 4 streams of data based on 4x4 (Transmit and Receive) optimized internal antennas • Multi-user MIMO (MU-MIMO) increases efficiency and capacity – enabling clients to utilize the RF spectrum much more efficiently by allowing multiple-AP-to client transmissions, beamforming, wider bandwidth, and improved encoding • AirQual feature enables spectrum analysis and interference identification • Centrally managed by Wireless Controllers • 2.5GBASE-T Multi-Gigabit support eliminates bottlenecks associated with standard Gigabit Ethernet (NBASE-T switch required to obtain speeds higher than 1Gbps w/ a single port) Fig. 2 Source: https://www.netgear.com/images/datasheet/wireless/WAC740.pdf, Page 1, last accessed Feb 08, 2021, Exhibit B **Citation 3: Product highlights**

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	MU-MIMO operates in the downstream direction (access point to client) and allows an access point to transmit to multiple client devices simultaneously. SU-MIMO (single-user, multiple-input, multiple-output) is the predecessor technology that was part of the 2009 IEEE 802.11n wireless standard as well as the 802.11ac Wave 1 standard. SU-MIMO also allows multiple simultaneous transmissions, but only to one client device at a time. MU-MIMO (802.11ac Wave 2) is like a switch: it allows simultaneous transmission of data to multiple clients. SU-MIMO (802.11n and 802.11ac Wave 1) is like a hub: it allows transmission to only one client at a time. Fig. 3 Source: https://kb.netgear.com/31309/What-is-MU-MIMO-and-how-can-this-technology-be-useful-in-my-network, Page 1, last accessed Feb 08, 2021, Exhibit H
1a. weighting a first data at said access point to transmit said first data using said first and second antennas so that said first mobile station only receives said first data; and **1b.** weighting a second data at said access point to transmit said second data using said first and second antennas so that said second mobile station only receives said second data;	The method practiced by the accused product comprises of weighting the first data at the said access point to transmit said first data using said first and second antennas so that said first mobile station only receives said first data and weighting a second data at the said access point to transmit said second data using said first and second antennas so that said second mobile station only receives said second data. The WAC740 AP uses explicit beamforming techniques as defined by the 802.11ac standard. By implementing Explicit feedback (i.e., Explicit beamforming), the accused products use the Channel Information or steering feedback received from the mobile stations to compute transmit steering vectors (i.e., steering matrix). See Fig. 4 and Fig. 5. The steering matrix (i.e., weighting information) is determined/calculated by the beamformer (i.e., the accused products) based on the CSI feedback provided by the beamformer (i.e., the client/mobile stations). Mathematically, a steering matrix describes the ability to steer the signals in the beamforming technique. The steering matrix is then applied to the data before transmission to ensure that the data reaches a particular receiver. See Fig. 6 and Fig. 7. **Citation 4: Explicit beamforming**

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	10. Does the WAC740 support explicit beamforming as defined by the 802.11ac standard? The WAC740 AP is compliant with 802.11ac explicit beamforming requirements. **11. What is explicit beamforming?** Explicit transmit beamforming is an advanced signal processing technique with multiple antenna communication. This technique utilizes the knowledge of the MIMO channel information to improve received signal quality at the receiver/client which results in better reception and hence throughput. Explicit beamforming involves the clients sending beamforming information based on the APs request. This request involves the AP sending channel training information which the client processes and feeds back to the AP. This processed information helps the AP achieve better transmission results. Fig. 4 Source: https://www.netgear.com/images/Products/Wireless/BusinessWireless/WAC740/NG-WAC740-802_11-FAQ.pdf, Page 2, last accessed Feb 08, 2021, Exhibit C **Citation 5: About Beamforming**

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	What is 11ac beamforming? Beamforming is a radio wave technology that is written into the next generation IEEE Wi-Fi 802.11ac standard. This technology allows the beamformer (Router) to transmit radio signal in the direction of the beamformee (Client), thus creating a stronger, faster and more reliable wireless communication. Think of beamforming as a radio transmission from the transmitter to the receiver, customized according to their relative locations. A NETGEAR router with Beamforming+ scans the entire wireless network, understands the parametric of each client, and optimizes the Wi-Fi communication with each client by transmitting focused and directional radio signals. **What are the benefits of beamforming?** The key benefits of beamforming are: • Extend Wi-Fi coverage and reduce dead spots. • Deliver stable Wi-Fi connection for voice and HD video. • Better Wi-Fi throughput • Reduces unnecessary RF interference Fig. 5 Source: https://kb.netgear.com/23503/Beamforming-FAQs, Page 1, last accessed Feb 08, 2021, Exhibit E

	Citation 6: Transmit beamforming - Implicit mode and Explicit mode **9.29 Transmit beamforming** ***Change 9.29.1 (including the subclause title) as follows:*** **9.29.1 ~~General~~ HT steering matrix calculations** In order for an HT beamformer to calculate an appropriate steering matrix for transmit spatial processing when transmitting to a specific HT beamformee, the HT beamformer needs to have an accurate estimate of the channel over which it is transmitting. Two methods of calculation are defined as follows: — *Implicit feedback*: When using implicit feedback, the beamformer receives long training symbols transmitted by the HT beamformee, which allow the MIMO channel between the HT beamformee and HT beamformer to be estimated. If the channel is reciprocal, the HT beamformer can use the training symbols that it receives from the HT beamformee to make a channel estimate suitable for computing the transmit steering matrix. Generally, calibrated radios in MIMO systems can improve reciprocity. See 9.29.2. — *Explicit feedback*: When using explicit feedback, the HT beamformee makes a direct estimate of the channel from training symbols sent to the HT beamformee by the HT beamformer. The HT beamformee may prepare CSI or steering feedback based on an observation of these training symbols. The HT beamformee quantizes the feedback and sends it to the HT beamformer. The HT beamformer can use the feedback as the basis for determining transmit steering vectors. See 9.29.3. Fig. 6 Source: https://ieeexplore.ieee.org/servlet/opac?punumber=7797533, Page 192, Last accessed Feb 08, 2021, Exhibit K **Citation 7: Beamforming steering matrix** **beamforming steering matrix**: A matrix that describes the mapping of space-time streams to transmit antennas and for which the values have been determined using knowledge of the channel between transmitter and receiver with the goal of improving reception at the receiver. Fig. 7 Source: https://ieeexplore.ieee.org/servlet/opac?punumber=7797533, Page 36, Last accessed Feb 08, 2021, Exhibit K The accused products transmit data to multiple stations (i.e., at least the first mobile station and second mobile station) using MU-MIMO and the corresponding beamforming technique. Explicit beamforming requires CSI to calculate the steering matrix. The accused products use the channel sounding process to perform the channel estimation (i.e., collect CSI information).

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	During the channel sounding process, the accused products (i.e., beamformer) send a Null Data Packet (NDP) Announcement frame to the mobile stations (i.e., beamformer). The stations provide a feedback matrix (i.e., CSI feedback) in response to the NDP frame. The accused products use the feedback matrix (i.e., including CSI for a wireless channel) to calculate a steering matrix (i.e., weighting information). **Citation 8: Requirement of Channel measurement procedure in 802.11ac** **Channel measurement (sounding) procedures** Beamforming depends on channel calibration procedures, called *channel sounding* in the 802.11ac standard, to determine how to radiate energy in a preferred direction. Many factors may influence how to steer a beam in a particular direction. Within the Fig. 8 Source: https://www.oreilly.com/library/view/80211ac-a-survival/9781449357702/, Page 83, Last accessed Feb 08, 2021, Exhibit F **Citation 9: Channel Sounding Procedure** Channel sounding consists of three major steps: 1. The beamformer begins the process by transmitting a Null Data Packet Announcement frame, which is used to gain control of the channel and identify beamformees. Beamformees will respond to the NDP Announcement, while all other stations will simply defer channel access until the sounding sequence is complete. 2. The beamformer follows the NDP Announcement with a null data packet. The value of an NDP is that the receiver can analyze the OFDM training fields to calculate the channel response, and therefore the steering matrix. For multi-user transmissions, multiple NDPs may be transmitted. 3. The beamformee analyzes the training fields in the received NDP and calculates a feedback matrix. The feedback matrix, referred to by the letter V in the 802.11ac specification, enables the beamformer to calculate the steering matrix. 4. The beamformer receives the feedback matrix and calculates the steering matrix to direct transmissions toward the beamformee. Fig. 9

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Source: https://www.oreilly.com/library/view/80211ac-a-survival/9781449357702/ , Page 84, Last accessed Feb 08, 2021, Exhibit F

Citation 10: Channel Sounding Procedure

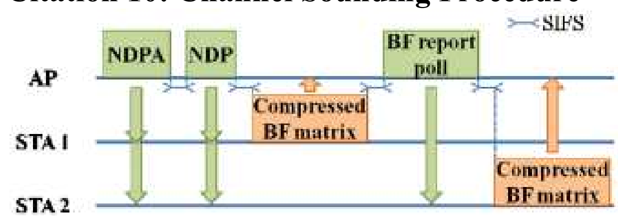

Fig. 1. IEEE 802.11ac channel sounding procedure for two stations

TABLE I. IEEE 802.11AC SOUNDING AND FEEDBACK PARAMETERS

Frames / Fields		Conditioning parameters
NDP		Beamformer's number of antennas
Compressed BF matrix	Signal to noise ratio information	Number of spatial streams
	Channel matrix element	Bandwidth
		Subcarrier grouping
		Beamformee's number of spatial streams
		Beamformee's number of antennas
		Number of angle quantization bits (Ψ and Φ)
	MU only information	Bandwidth
		Subcarrier grouping
		Beamformee's number of spatial streams

Fig. 10

Source: https://ieeexplore.ieee.org/document/6328529, Page 2, Last accessed Feb 08, 2021, Exhibit I

As an example, the AP (e.g., WAC70) is connected to two mobile stations (Ma and Mb). Initially, the AP uses the channel sounding procedure with Ma to obtain the CSI feedback for the wireless channel between AP and Ma (i.e., first wireless channel). Based on the CSI received, the AP estimates/calculates the steering matrix (i.e., weighting information) to steer the beam towards Ma so that the first data is

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	received only by Ma. Further, the AP applies the steering matrix (i.e., weighting information) to the first data and transmits it to Ma by beamforming via the antennas (i.e., first and second antennas). A similar procedure is followed simultaneously to transmit the data to Mb. Fig. 11 shows that the steering matrix (i.e., weighting information) is applied to transmission data. **Citation 11: Steering matrix (weighting) applied to the data** path to the receiver in one operation. Naturally, after applying the steering matrix to the data for transmission, it will leave the antenna array in a decidedly non-omnidirectional pattern. Fig. 11 Source: https://www.oreilly.com/library/view/80211ac-a-survival/9781449357702/ , Page 84, Last accessed Feb 08, 2021, Exhibit F
1c. increasing a first data rate of transmission of said first data and a second data rate of transmission of said second data using a single carrier frequency in a radio frequency communication based on a transmission protocol;	The method practiced by the accused product comprises increasing a first data rate of transmission of said first data and a second data rate of transmission of said second data using a single carrier frequency in a radio frequency communication based on a transmission protocol. The WAC740 AP supports MU-MIMO beamforming to transmit data to multiple clients simultaneously when the clients require more throughput and all the clients connected to the AP support MU-MIMO, the network switch to MU-MIMO beamforming. MU-MIMO beamforming provides features such as higher throughput (i.e., data transmission rate) as compared to SU-MIMO. The MU-MIMO beamforming may take place over a single carrier radio frequency, e.g., 5 GHz. In this manner, the AP increase data rates (or first and second data rates) for clients by increasing throughputs using a single carrier frequency. See Fig. 12 - Fig. 15. **Citation 12: Operable frequency channels**

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	Product Highlights • Features 802.11ac Wave 2 technology providing a theoretical aggregate throughput of 2.3Gbps—roughly double the rates offered by today's high-end 802.11ac access points • Reliable wireless coverage with 4 streams of data based on 4x4 (Transmit and Receive) optimized internal antennas • Multi-user MIMO (MU-MIMO) increases efficiency and capacity – enabling clients to utilize the RF spectrum much more efficiently by allowing multiple-AP-to client transmissions, beamforming, wider bandwidth, and improved encoding • AirQual feature enables spectrum analysis and interference identification • Centrally managed by Wireless Controllers • 2.5GBASE-T Multi-Gigabit support eliminates bottlenecks associated with standard Gigabit Ethernet (NBASE-T switch required to obtain speeds higher than 1Gbps w/ a single port) **Features** • MU-MIMO maximizes the use of wireless medium for delivery of high throughput content • Compact and elegant design stylishly blends into the environment • Concurrent operation in 2.4GHz (600Mbps) and 5GHz (1.7Gbps) for maximum wireless throughput • Backward compatibility with 802.11a, 802.11b, 802.11g, and 802.11n network devices • Integrated 802.3at Power over Ethernet (PoE+) lowers deployment costs • Controller managed by WC7500, WC7600 and WC9500 allowing centralized management up to 600 Access Points in a cluster of controllers. • Business-class security features include WPA, WPA2, rogue AP detection and 802.1x with RADIUS support • Easy mounting mechanism for quick wall or ceiling installation • Internal antennas factory-optimized for maximum RF performance • Antenna take-offs enable optional accessory antenna attachment for 2.4GHz and/or 5GHz operations • AirQual monitors Wi-Fi channel utilization on the network, identify sources of interference. Log alerts on channel quality drop or overload Fig. 12 Source: https://www.netgear.com/images/datasheet/wireless/WAC740.pdf, Page 1, last accessed Feb 08, 2021, Exhibit B **Citation 13: MU-MIMO vs SU-MIMO**

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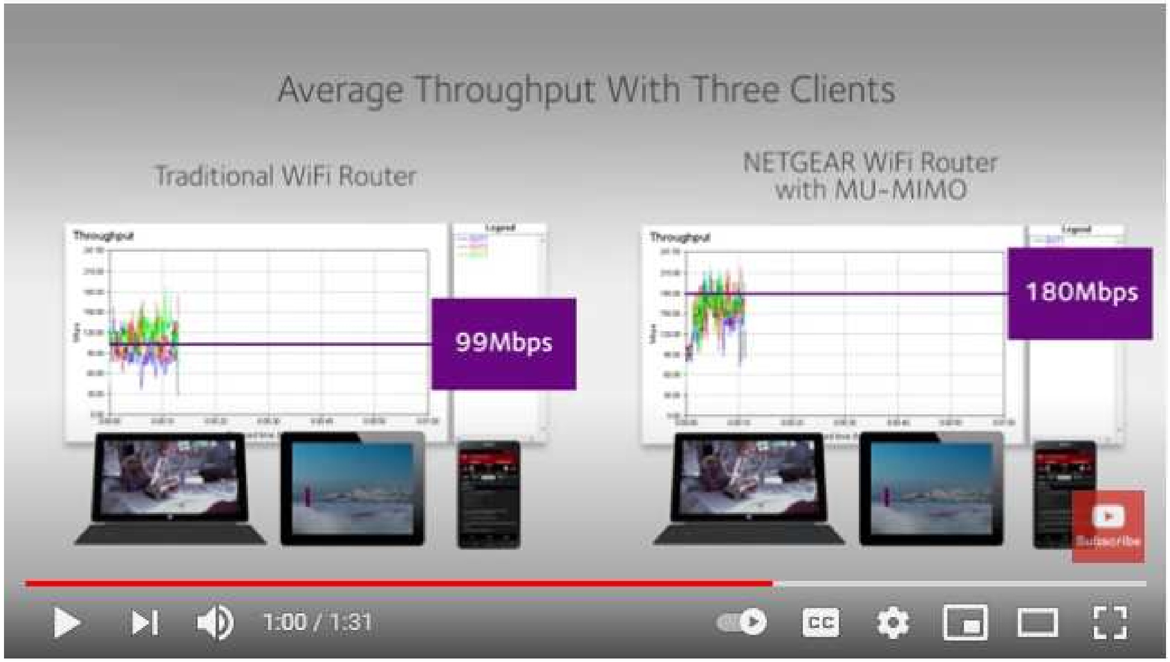
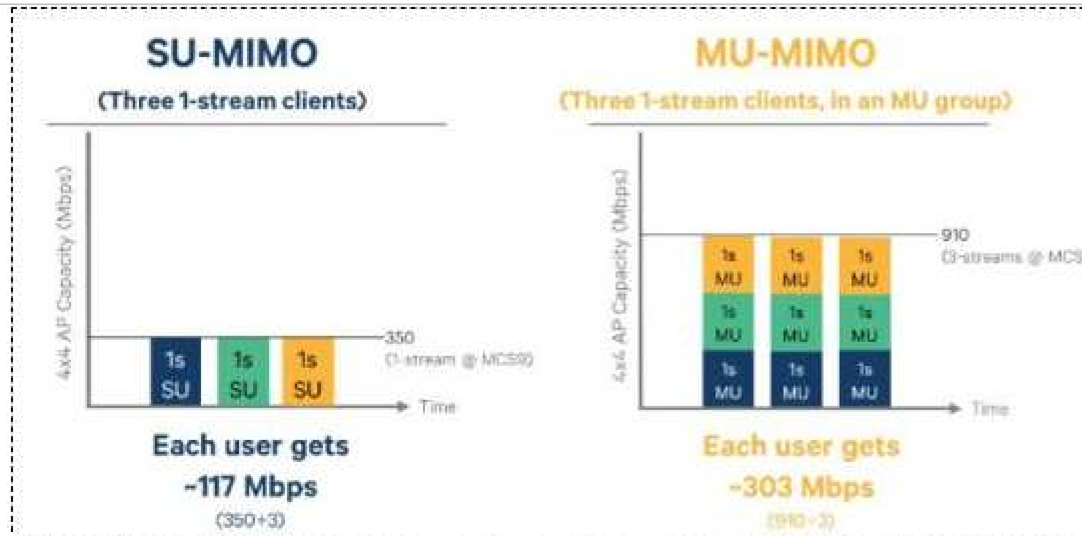
	What is MU-MIMO? MU-MIMO stands for multi-user, multiple-input, multiple-output, and it is a new feature in IEEE 802.11ac Wave 2. The 802.11ax WiFi standard enables MU-MIMO to support more clients than ever. For example, the RAX200 communicates with multiple client devices simultaneously. MU-MIMO operates in the downstream direction (access point to client) and allows an access point to transmit to multiple client devices simultaneously. SU-MIMO (single-user, multiple-input, multiple-output) is the predecessor technology that was part of the 2009 IEEE 802.11n wireless standard as well as the 802.11ac Wave 1 standard. SU-MIMO also allows multiple simultaneous transmissions, but only to one client device at a time. MU-MIMO (802.11ac Wave 2) is like a switch: it allows simultaneous transmission of data to multiple clients. SU-MIMO (802.11n and 802.11ac Wave 1) is like a hub: it allows transmission to only one client at a time. If you want to use MU-MIMO in your home or business wireless network, both the client device and the access point must support 802.11ac Wave 2 MU-MIMO. Fig. 13 Source: https://kb.netgear.com/31309/What-is-MU-MIMO-and-how-can-this-technology-be-useful-in-my-network, Page 1, last accessed Feb 08, 2021, Exhibit H **Citation 14: MU-MIMO providing high speed**

US7512096B2	Netgear WAC740 Wireless Access Point
	 Fig. 14 Source: https://www.youtube.com/watch?t=46&v=AsOp6_R_q54&feature=youtu.be, Page 1, last accessed Feb 08, 2021, Exhibit G **Citation 15: MU-MIMO vs SU-MIMO**

US7512096B2	Netgear WAC740 Wireless Access Point
	 Fig. 15 Source: https://www.smallnetbuilder.com/wireless/wireless-features/32725-why-youll-want-mu-mimo, Page 2, last accessed Feb 08, 2021, Exhibit J
1d. discriminating transmissions of said first and said second data on a downlink in said radio frequency communication based on a spatial dimension;	The method practiced by the accused product comprises discriminating transmissions of said first and said second data on a downlink in said radio frequency communication based on a spatial dimension. The set of active STAs is grouped in spatially compatible groups, which can be served by MU-MIMO, where each group consists of a set of active STAs which can be separated in the space domain (spatial dimension). Accordingly, the first and second data corresponds to the first and second groups. See Fig. 16. **Citation 16: Spatially compatible groups**

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	V. PROBLEM STATEMENT Our main objective is to maximize the average DL rate in each cell which indicates the overall effectiveness of an AP. As we assumed a WiFi network with unequal network load our objective can be achieved by optimizing the DL throughput of highly loaded APs. In particular lightly loaded APs can perform interference nulling towards STAs located in adjacent hotspot cells/AP resulting in reduced co-channel interference and hence increased rate in hotspot cells. However, selecting the most suitable MIMO transmission modes for each DL transmission in each cell is a complex task which depends on a multitude of aspects. Therefore, in order to reduce complexity we propose the following heuristic which leads us to a two-step approach: 1) ***Space-Division Multiple Access (SDMA) within a cell***: Serve the active STAs within each cell using SDMA (DL MU-MIMO) which is very effective as the APs are equipped with antenna arrays (ULA) whereas the STAs have just a single antenna. In particular we have to create spatially compatible SDMA groups, where each group consists of a set of active STAs which can be separated in the space domain. Fig. 16 Source: https://ieeexplore.ieee.org/document/7416948, Page 2, last accessed Feb 08, 2021, Exhibit D
1e. applying a space division multiple access based on said transmission protocol to said transmissions to transmit said first and said second data substantially concurrently from said access point	The method practiced by the accused product comprises applying a space division multiple access based on said transmission protocol to said transmissions to transmit said first and said second data substantially concurrently from the said access point to said first and second mobile stations. MU-MIMO is also known as Space Division Multiple Access (SDMA) where the transmitter can send different signals simultaneously towards multiple users (mobile stations) without causing interference

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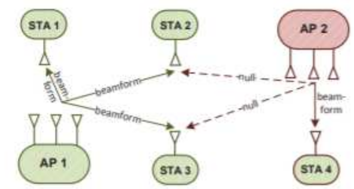
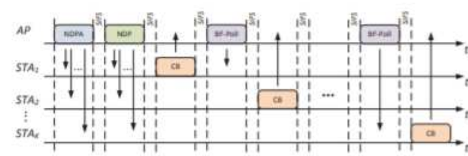
to said first and second mobile stations, respectively;	by using the transmit beams. For example, beam associated with first and second data is directed towards first and second mobile stations, respectively. See Fig. 17 and Fig. 18. **Citation 17: Sending Beams**  Fig. 1: AP 1 performs MU-MIMO by steering multiple beams towards its STAs 1-3 whereas AP 2 beamforms its signal to STA 4, while nulling interference to STA 2 & 3.  Fig. 2: Channel sounding in IEEE 802.11ac. selected to beamform the signal towards a single user (SU-MIMO), whereas with MU-MIMO also known as Space-Division Multiple Access (SDMA) the transmitter can send different signals simultaneously towards multiple users without causing interference by using the transmit beams (Fig. 1). A common beamforming technique is the Zero-Forcing [1] that introduces nulls in the directions of the interferers. For the focus of this paper the possibility to use MIMO for interference management is important. With the help of beamforming a transmitter can perform interference nulling which allows him to completely cancel (i.e., null) its signal at a particular receiver (Fig. 1). This is a promising way to manage interference between co-located cells/APs using the same radio spectrum. Fig. 17 Source: https://ieeexplore.ieee.org/document/7416948, Page 2, last accessed Feb 08, 2021, Exhibit D

US7512096B2	Netgear WAC740 Wireless Access Point
	Citation 18: Spatially compatible groups V. PROBLEM STATEMENT Our main objective is to maximize the average DL rate in each cell which indicates the overall effectiveness of an AP. As we assumed a WiFi network with unequal network load our objective can be achieved by optimizing the DL throughput of highly loaded APs. In particular lightly loaded APs can perform interference nulling towards STAs located in adjacent hotspot cells/AP resulting in reduced co-channel interference and hence increased rate in hotspot cells. However, selecting the most suitable MIMO transmission modes for each DL transmission in each cell is a complex task which depends on a multitude of aspects. Therefore, in order to reduce complexity we propose the following heuristic which leads us to a two-step approach: 1) ***Space-Division Multiple Access (SDMA) within a cell***: Serve the active STAs within each cell using SDMA (DL MU-MIMO) which is very effective as the APs are equipped with antenna arrays (ULA) whereas the STAs have just a single antenna. In particular we have to create spatially compatible SDMA groups, where each group consists of a set of active STAs which can be separated in the space domain. Fig. 18 Source: https://ieeexplore.ieee.org/document/7416948, Page 2, last accessed Feb 08, 2021, Exhibit D
1f. defining at least one of said access point, said first and second mobile stations, and said downlink at least in part by Institute of Electrical and Electronics Engineers (IEEE) 802.11 standard to establish said network including a wireless local area network;	The method practiced by the accused product comprises defining at least one of the said access points, said first and second mobile stations, and said downlink at least in part by the Institute of Electrical and Electronics Engineers (IEEE) 802.11 standard to establish said network including a wireless local area network. The WAC740 works on the Institute of Electrical and Electronics Engineers 802.11ac wifi standard. The standard defines a wireless infrastructure network consisting of multiple APs with overlapping cells involving the downlink process. See Fig. 19 - Fig. 21. **Citation 19: About WAC740**

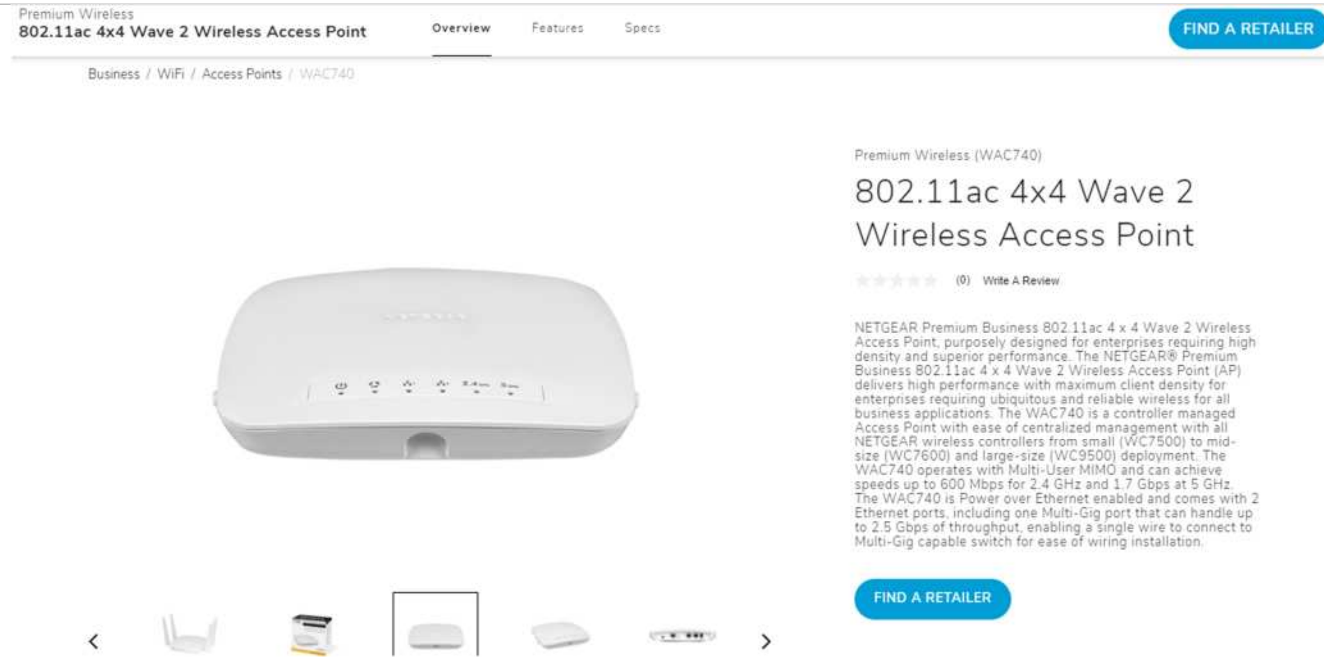
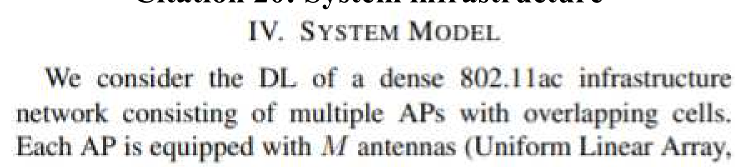


Fig. 19

Source: https://www.netgear.com/business/wifi/access-points/wac740, Page 1, Last accessed Feb 08, 2021, Exhibit A

Citation 20: System infrastructure



IV. SYSTEM MODEL

We consider the DL of a dense 802.11ac infrastructure network consisting of multiple APs with overlapping cells. Each AP is equipped with M antennas (Uniform Linear Array,

Fig. 20

Source: https://ieeexplore.ieee.org/document/7416948, Page 2, Last accessed Feb 08, 2021, Exhibit D

The set of active STAs (includes first and second mobile stations) corresponding to each cell (AP) are grouped in spatially compatible groups and are served by the multiple user MIMO. See Fig. 21.

US7512096B2	Netgear WAC740 Wireless Access Point
	Citation 21: Access points in the network **Contributions:** In this paper we show that the *combination* of two well-known physical layer MIMO techniques, i.e. MU-MIMO and nulling, is beneficial in the downlink (DL) of dense 802.11ac-based infrastructure WiFi networks with unequal network load. The proposed algorithm performs in two steps. First, the set of active STAs in each cell (AP) are grouped in spatially compatible groups which can be served by DL MU-MIMO. These STAs are periodically sounded by the AP they are associated with in order to keep instantaneous CSI up-to-date. Second, to achieve high spectral efficiency a frequency reuse one scheme together with interference management where the unused degree of freedom of lightly loaded cells/APs is utilized to perform null steering towards STAs in highly loaded adjacent cells. In order to keep the channel sounding overhead low, the proposed algorithm estimates the STAs to be nulled using just the average received power values. The proposed method is analyzed by means of simulations in an indoor hotspot environment. Fig. 21 Source: https://ieeexplore.ieee.org/document/7416948, Page 1, last accessed Feb 08, 2021, Exhibit D
1g. coupling said access point to said first and second mobile stations through said wireless local area network;	The method practiced by the accused product comprises coupling said access point to said first and second mobile stations through said wireless local area network. An AP serves the active STAs (i.e., first and second mobile stations) through the wireless infrastructure network. See Fig. 22. **Citation 22: STAs and AP are coupled** ULA) whereas the STAs have just a single antenna. Next, the number of active STAs served by each AP is not the same. There are locations where APs serve only a small number of STAs, i.e. floors, and hotspots where only a few APs have to serve a huge number of STAs, i.e. conference room. Further, we assume that the total available spectrum can be used simultaneously in an efficient way (e.g. using channel bonding as specified in 802.11ac). Finally, all the APs are connected to a wired backbone, e.g. Ethernet, and hence can be efficiently controlled by a centralized controller.

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	Fig. 22 Source: https://ieeexplore.ieee.org/document/7416948, Page 2, last accessed Feb 08, 2021, Exhibit D
1h. estimating a first radio channel from said access point to said first mobile station over a pilot interval; **1i.** And estimating a second radio channel from said access point to said second mobile station over said pilot interval.	The method practiced by the accused product comprises estimating a first radio channel from said access point to said first mobile station over a pilot interval and estimating a second radio channel from the said access point to the said second mobile station over said pilot interval. The APs estimate radio channels to transmit data simultaneously to multiple stations (or, first mobile stations and second mobile station) during MU-MIMO. The AP uses the channel sounding process to perform this estimation. During the channel sounding process, the AP sends a Null Data Packet (NDP) Announcement frame to the stations. The stations provide their beamforming matrices in response to the NDP frame. This matrix data is used for channel estimation. The channel sounding process is performed frequently over channel sounding interval (i.e., pilot interval. See Fig. 24 - Fig. 26. Fig. 23 shows that pilot carriers are used for channel tuning operations, including channel estimation and synchronization. **Citation 23: Channel sounding process in MU-MIMO** Pilot carriers are a form of overhead used in OFDM, and they represent an overhead for the channel. In MIMO systems, a single pilot carrier can be more effective at assisting with the channel tuning operations. As a result, the pilot overhead in 802.11ac has almost a "bulk discount" effect with the wider channels. Table 2-1 identifies the OFDM carrier numbering and pilot channels. The range of the subcarriers defines the channel width itself. Each subcarrier has identical data-carrying capacity, and therefore, more is better. Pilot subcarriers are protocol overhead and are used to carry out important measurements of the channel. The table shows that as the channel size increases, the fraction of the channel devoted to pilot carriers decreases. As a result, the channel becomes more Fig. 23 Source: https://www.oreilly.com/library/view/80211ac-a-survival/9781449357702/, Page 31, Last accessed Feb 08, 2021, Exhibit F

US7512096B2	Netgear WAC740 Wireless Access Point
	Citation 24: Channel sounding process in MU-MIMO III. CHANNEL SOUNDING AND FEEDBACK IN IEEE 802.11AC Let us take a closer look at the channel sounding and feedback protocol in 802.11ac. In the previous 802.11n standard, the multiplicity of options for the sounding protocol has made things difficult for interoperability when using beamforming (BF) techniques [6]. Consequently, 802.11ac uses a unique protocol based on the use of a null data packet (NDP) for channel sounding and compressed beamforming matrices for feedback. *1) Protocol* As illustrated in Fig. 1, the AP announces the beginning of a sounding procedure through a NDP announcement (NDPA) frame [1]. In it the AP advertizes the beamformees' addresses (through a group identifier) and specifies the address of the Fig. 24 Source: https://ieeexplore.ieee.org/document/6328529, Page 2, last accessed Feb 08, 2021, Exhibit I **Citation 25: Channel sounding process in MU-MIMO**

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	first responding beamformee. The concerned stations can thus prepare themselves to receive the upcoming NDP frame, and consequently compute their respective beamforming matrices. The frame exchange is punctuated with short inter-frame sequences (SIFS). Upon reception of the NDP, the first responding station replies immediately after with the compressed version of its BF matrix. The AP then polls the remaining stations for their respective BF matrices. For practical reasons, the maximum number of beamformees per group is limited to four [6]. The reader shall note that for single-user (SU) beamforming, the protocol ends after the first feedback frame. In addition, stations can send sounding frames to the AP, but for single user beamforming ends. *2) Parameters* The duration of the channel sounding procedure depends on the parameters given in Table I. Clearly the main parameters are the number of beamformees and the number of spatial streams. Another overhead adding parameter is the channel sounding interval. As explicated in [6], MU-MIMO is much more sensitive to feedback errors and aging than classical single user MIMO (SU-MIMO) beamforming. This implies that channel sounding has to be done more frequently than for SU-MIMO. There is no indication on which interval to take in the standard but studies show that it will be smaller than SU-MIMO's 100 ms [4]. Fig. 25 Source: https://ieeexplore.ieee.org/document/6328529, Page 2, last accessed Feb 08, 2021, Exhibit I **Citation 26: Channel sounding process in MU-MIMO**

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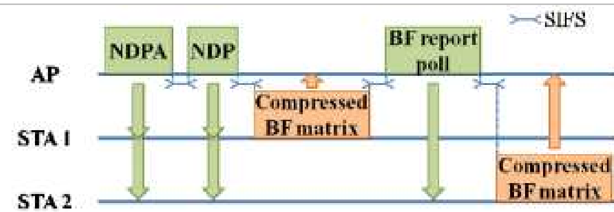

Fig. 1. IEEE 802.11ac channel sounding procedure for two stations

TABLE I. IEEE 802.11AC SOUNDING AND FEEDBACK PARAMETERS

Frames / Fields		Conditioning parameters
NDP		Beamformer's number of antennas
Compressed BF matrix	Signal to noise ratio information	Number of spatial streams
	Channel matrix element	Bandwidth
		Subcarrier grouping
		Beamformee's number of spatial streams
		Beamformee's number of antennas
		Number of angle quantization bits (Ψ and Φ)
	MU only information	Bandwidth
		Subcarrier grouping
		Beamformee's number of spatial streams

Fig. 26

Source: https://ieeexplore.ieee.org/document/6328529, Page 2, last accessed Feb 08, 2021, Exhibit I

References Cited

Exhibit(s)	Description	Link
Exhibit A	WAC740 4 x 4 Wave 2 Wireless-AC	https://www.netgear.com/business/wifi/access-points/wac740
Exhibit B	Premium 4x4 Dual Band 802.11ac Wave 2 Access Point	https://www.netgear.com/images/datasheet/wireless/WAC740.pdf
Exhibit C	Frequently Asked Questions	https://www.netgear.com/images/Products/Wireless/BusinessWireless/WAC740/NG-WAC740-802_11-FAQ.pdf
Exhibit D	Downlink MIMO in IEEE 802.11ac-based Infrastructure Networks	https://ieeexplore.ieee.org/document/7416948
Exhibit E	Beamforming FAQs	https://kb.netgear.com/23503/Beamforming-FAQs
Exhibit F	802.11ac Survival Guide	https://www.oreilly.com/library/view/80211ac-a-survival/9781449357702/
Exhibit G	MU-MIMO Matters	https://www.youtube.com/watch?t=46&v=AsOp6_R_q54&feature=youtu.be
Exhibit H	What is MU-MIMO	https://kb.netgear.com/31309/What-is-MU-MIMO-and-how-can-this-technology-be-useful-in-my-network
Exhibit I	PHY+MAC channel sounding interval analysis for IEEE 802.11ac MU-MIMO	https://ieeexplore.ieee.org/document/6328529
Exhibit J	Why You'll Want MU-MIMO	https://www.smallnetbuilder.com/wireless/wireless-features/32725-why-youll-want-mu-mimo
Exhibit K	IEEE – 802.11ac 2013 amendment	https://ieeexplore.ieee.org/servlet/opac?punumber=7797533